

Tindley A, Wodehouse A. [Design, Technology and Communication within the British Empire, 1830-1914](#). Palgrave Macmillan UK, 2016

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## Introduction: Designing the empire

The locomotive was a symbol of design that reached the most remote corners of the British empire: an engineering marvel of a scale and complexity staggering to those unfamiliar with such machines. Heaving through the colonial bush, it could induce, ‘stampedes of the natives,’ with a blow of its whistle, and served as a reminder of Britain’s power as much as solving logistical issues.<sup>i</sup> Successful and sustainable adaptation of technology, however, meant a deep understanding of colonial conditions was crucial. What commercial factors influenced the chosen route? How was the line plotted and the engine specified to cope with the local environment? Who collaborated to manufacture and assemble the locomotive itself? And what relationships formed in the installation and operation of this new mode of transport? The stories behind not just locomotives but many of the iconic technologies of the industrial revolution are bound up in the process of their realisation – their design in the broadest sense of the word.

In focusing on the intensely collaborative nature of design, we examine the multifarious links formed in supporting the industrialisation of Britain’s empire, and uncover the motivations, dynamics and legacies of those working within its structures. There has been broad historical debate on the nature of imperial linkages, with networks, bridgeheads, nodes and webs among the proposed structures and definitions put forward. The long-standing discussion around, firstly, the diffusion, and latterly, the transfer of technology, has contributed a great deal to this wider debate, and has built a postcolonial historiographical position that de-centres Europe and emphasises instead the circularity of imperial connections. *Design and Communication* seeks to add to this debate by focusing not on the technologies themselves, but on their exploitation and the way the design process acted as a conduit for communication between, across and within Britain and the empire.

Our central research question interrogates the role of design in communicating and applying industrial technologies to culturally diverse imperial locations between *circa* 1830 and the First World War. Rather than examining the impacts

of the technologies – particularly revolutionary technologies and their multiple incarnations, such as steam power – we focus on incremental and adaptive design developments, which accounts for the majority of innovative activity in this period. Through the processes of identification, specification and application to and for new environments, we argue that design acted as a conduit for intra-imperial communication in the long nineteenth century; that is, as a form of communication within and across the different internal British contexts and the myriad, expanding imperial contexts. We examine the adaptation of industrial technologies for specific purposes and examine the practical communication and links that emerged as necessities of their realisation.<sup>ii</sup> *Design and Communication* utilises detailed archival case studies to explore the mechanics of collaboration, and poses two fundamental questions: what was the nature of design in the British empire with regards to location, stakeholders, motivation and format? And what do both the opportunities and restrictions posed by the imperial context tell us about how design functioned as a conduit for communication?

We also hope to shed fresh light on the semantics, politics, and conceptualisation of the term ‘design’. Design is such a widely used term (noun, verb, adjective, cross-sector, positive/pejorative) that it is difficult to define, both historically and particularly in contemporary contexts. There has been increasing consideration of ‘design thinking’ and how it can aid innovation. Yet during the chronology studied here, the terms design and innovation were entirely unused, or barely so. Instead, the ‘betterment’ that was part of the overall conception of the empire project and the assertion of new ways of life were tied up with the growing faith in the developments in technology, science and medicine that were taking place.<sup>iii</sup> Often, significant engineering risks – and all the design work documented here was undertaken by engineers – were taken, and huge resources spent on projects: contextualising these in relation to the tentacles of empire at each stage of the product development process should be illustrative for both design scholars and historians. Design in this book is therefore considered a conduit for communication. As the mechanism by which ideas became reality, it enabled links between people and organisations through the exchange of information, logistical movement of goods, installation of facilities

and use of equipment. Design has also been described as a social process, and the necessity of engaging a range of stakeholders made it a critical component in understanding the establishment and development of links between and within Britain and the imperial territories.<sup>iv</sup> While the installation of finished artefacts (railways, production machinery, agricultural equipment, bridges) signified the reach of the British empire, it was the *process of design itself* that helped to reinforce these links. In applying these interpretations as a framework to examine how technologies were used and applied in the British empire, we hope to contribute to the understanding of the nature of design during this period. The rapid technological breakthroughs, environmental challenges, disparate markets and institutional networks are the backdrop to the story of how the process of design was a powerful driver in shaping the relationship between Britain and its colonies.<sup>v</sup>

As such, *Design and Communication* situates itself in three key areas of historical enquiry and literature: the imperial – including imperial economics and shifting ideas of colonial knowledge; the industrial – including business models and patents; and lastly, design and innovation – both theoretical and practical.<sup>vi</sup> It seeks to make a contribution to each of these areas by utilising a detailed case study approach that encompasses a range of industrial technologies (railways, steam ploughs, sheep shears, bridges, sugar production and road steamers) to test some of the wide-ranging claims and ideas debated in the over-arching literature.

In order to understand our case studies, we have had to consider carefully the very different imperial contexts in which technologies were identified, designed and developed. These included formal and informal imperial structures, the financial and economic linkages of empire, widely varied constitutional and institutional structures, and professional networks. A key intellectual context for our work has been that of P. J. Cain and A. G. Hopkins, with their emphasis on the financial and economic linkages of empire and ‘gentlemanly capitalism’.<sup>vii</sup> The development of design was at the heart of an international economy: an extension of capitalism into and across wildly varying territories over the

globe.<sup>viii</sup> The importance placed by these authors on the financial and economic circuits of empire, and their ‘gentlemanly’ drivers are borne out at least to some extent by our work. In nearly all of our case study technologies, elite wealth, but more importantly, elite connections – be they British or among and across colonised peoples – were key.<sup>ix</sup> Most involved incremental improvement to existing industrial equipment, rather than the revolutionary inventions or technology systems that dominate popular thinking about the industrial revolution, such as steam power or the telegraph. What we show is the importance of elites – British or colonial – and their patronage, networks and funds in the innovation process. This was as true for the formal empire of crown colonies and dominions as it was of the informal empire, such as Cuba, Argentina and Peru.<sup>x</sup>

Laidlaw describes a general transition from 1830 onwards from imperial control towards more pragmatic forms of administration and management in colonial settings.<sup>xi</sup> Variances in socio-economic, technological and cultural status, however, meant different imperial territories absorbed technologies at different rates. Part of this particular strand of the literature directs us to a discussion around the impact of constitutional and institutional imperial structures and to what extent any imperial territory (formal or informal) was a ‘captive market’ for British engineers and businesses looking for new opportunities. This contributes to a long-standing debate in the literature, with more recent work by Thompson and Magee nuancing – indeed, breaking down to some extent – the idea of the captive market, particularly in relation to the dominions.<sup>xii</sup> Requiring separate consideration is the status and governance of British India: most historians agree that India was different, both from the dominions of course, but also from other crown colonies, particularly those in the African continent. The level of centralised control wielded by the Government of India and its specific strategic, military and economic drivers does set it apart.<sup>xiii</sup> However, this does not matter so much to our interrogation. Design was still the conduit across all the different colonial settings, including India, and – crucially – within different settings within Britain too, which was often the locus of design activity.<sup>xiv</sup>

This brings us to one of the other major themes of imperial and technological histories: that of the forms and structures of inter-imperial communication – the networks, webs, nodes and circuits that have variously been suggested as constituting the structures of communication between and within Britain and its empire.<sup>xv</sup> *Design and Communication* subscribes to the postcolonial model put forward by Arnold which describes a circularity of information, experience and expertise through a variety of feedback loops, rather than a simple model of either diffusion or transfer.<sup>xvi</sup>

The notion of bridgeheads has also been developed as a model for communication specifically within the engineering profession, and although useful in that context, it is not a model that we closely adhere to here.<sup>xvii</sup> The less structured concept of circuits of empire fits what we have traced in the history of design communication more closely.<sup>xviii</sup> One of the reasons for this is the importance in our framework of the geographies of motivation for creating and then exporting or importing new or adaptive design in both the British and imperial contexts. As will become clear, we are interested not just in the work itself but where and how it was being undertaken through the stages of the design process – identification, specification, conceptualisation and production. By focusing on this, we stress the importance of the circularity of inter-imperial communication rather than a hierarchy-focused approach.<sup>xix</sup>

Another important contextual consideration is the structure and setting for design activity within businesses and organisations, including their search for new work and opportunities, expansion via establishing overseas branches, partnerships with other companies and the requirement to develop design and manufacturing protocols.<sup>xx</sup> Often, even if a particular product became obsolete over time, these structures remained as the legacy of the design process and the communication therein – and the circuit through which future and new design was realised. To help situate our thinking in this particular field, we also utilise business history literature, including that which examines the family business model, the impact of social and/or religious networks on business formation and the frequent mergers and collaboration of businesses to meet large or

challenging projects.<sup>xxi</sup> This also connects our thinking to the nature of professional networks in the design context and how they can be uncovered and analysed through the archival evidence of design work – the journals, letters pages, reports, correspondence, newspapers and trade journals which form the foundations of an emerging profession.<sup>xxii</sup> Our research found these forms of communication more imperative than those represented by the patent system, although patents did play a role in some of our case study technologies.<sup>xxiii</sup> The literature continues to debate whether patents in the nineteenth century were more of a restriction than an opportunity, and although we would not suggest they acted uniformly as a restriction in the examples explored here, we would certainly not argue either that they acted as a primary driver for innovation.<sup>xxiv</sup>

One final area of contribution to the imperial literature is around the concept of colonial knowledge, and the kinds of opportunities and restrictions it generated in the communication of design.<sup>xxv</sup> Our research suggests that assumptions on the part of British engineers and companies about colonial territories and their peoples often led to the restriction rather than the best exploitation of new opportunities. It is important not to attempt to see the impact of colonial knowledge as something static, however: it changed over time and in different ways. What people thought they knew and how they applied their assumptions also altered according to geography as well as temporality, and key to understanding this is how British people viewed and understood their empire.<sup>xxvi</sup>

### ***Framework, case studies and archives***

*Design and Communication* has been structured around a set of four stages defining the design process, which allow for the distinct characterisation of communication through the innovation cycle. These are: identification, specification, conceptualisation and production. For each stage, multiple case study technologies are utilised to illuminate what was actually happening on the ground. This concern with the practicalities of the communication of design has informed the book's structure, approach and archival methodologies.

As the first stage, the principles of identification for both design and market opportunities in Britain and the imperial context are interrogated. In order to understand the drivers for new or adapted design we must define the mechanisms of market identification, and the processes by which technologies were aligned with emerging opportunities. The possession of the formal (and informal) empire did not necessarily provide unfettered access to markets – there were as many obstacles to the communication of design as there were advantages, as our case studies will demonstrate. The second stage is specification, whereby the requirements of the imperial context were more closely mapped out according to the specific user and/or customer requirements.<sup>xxvii</sup> A significant part of this stage of the design process was the impact of competition: including highly influential contracting competitions staged by various imperial authorities and administrations, principally to build major infrastructures such as bridges and railways.<sup>xxviii</sup> As such, much of the specification for these designs already existed in outline, and engineers and companies had to respond directly to these. The third stage in the process is conceptualisation, the means by which engineers generate, evaluate and refine new or adapted design configurations. This includes patterns of design generation, the role of collaboration, at individual or institutional level, and a discussion as to whether patents acted as a form of communication in this specific context. The fourth stage combines detailed design, production and distribution: the designed product made real. This includes the processes by which designs were converted into working prototypes and tested, the establishment of production processes, identification of labour skills and the transfer, or distribution, of the technology.

It is important to outline and define our terminology: most importantly, what do we mean by design communication? We take it to constitute multiple forms of knowledge and information exchange rather than an event: by engaging in the design process, individuals and businesses collaborate to achieve a shared goal. That is, communication is what is happening as part of the design process. *Design and Communication* questions where the centre of gravity in these processes lies, how that might change according to period, technology and location, and how



legacies of communication were created. To encompass the British empire, the informal empire and other territories where Britain had influence or British firms operated, we have used the term 'British World'. What emerges is a multiplicity of connections in the dissemination and development of design. The design process, as defined here, is a conduit: a temporary undertaking which brings together stakeholders around one design or artefact and then dissipates, often leaving permanent links or traces behind – whether in the form of documented protocols, standards, and institutions, or more intangible legacies in cultural perceptions and social relationships. As well as being a conduit, design is also a motivator which draws on people, businesses and resources in the creation of new connections to meet the desired outcome; it is a means to develop networks that facilitate the successful transfer of information and technologies. Lastly, we must consider the inventors, entrepreneurs and engineers who were behind new and adapted design. We do not use the definition 'designer', as this was not a recognised term in the period under discussion. Instead, many roles might be taken on by one individual – at once an inventor, engineer and entrepreneur. Collaboration and collaborative working was vital throughout the design process, and our examples will show exemplars within and across companies, between engineers, their customers, and labour forces, and in many other forms depending on the context.

Constituting an interdisciplinary team of historian and design engineer, the authors combine different methodologies in order to throw light on the ways in which design acted as a conduit for communication during the height of Britain's imperial project. In order to uncover the working design practices in this period – from the initial identification of markets through to the final application of designs in new contexts – six key technological case studies have been utilised, all industrial in nature. While an examination of domestic or consumer products may have proven illuminating particularly from a cultural perspective, we would have found more instances of self-contained development by companies who, despite shipping to colonial markets, did not engage in the same depth of communication. Furthermore, it is not the purpose of this book to explore in detail what happened to technology after it was embedded in the imperial

context: extensive and valuable work has already been done on this aspect of the movement of technology and design.<sup>xxix</sup> Instead, we wanted to break down the social processes and circuits by which design opportunities were developed by British companies, entrepreneurs and engineers. Industrial examples typically involved large, complex machines that required a diverse range of stakeholders to bring them to life, and therefore suited the nature of our investigation. Undoubtedly linked to the greater number of collaborators, the associated archives in these areas were also more extensive, allowing a richer recreation of communication patterns. In focussing on industrial technology, some areas were clearly attractive: trains, bridges, and coin minting were key instruments of empire and well-documented in the archives. We interrogated these from a holistic perspective, attempting to connect design information (technical drawings, engineers' notebooks etc.) with economic and social documentation (correspondence, catalogues, order books, news reports etc.). Our other technologies – steam ploughs, sheep shears and road steamers – are more focussed and experimental areas where response to the colonial context was central to their development. Tracing the evolution of these examples over time was particularly informative.

Most of the archives have come via the British headquarters of businesses, although the records of the myriad networks of overseas partnerships, governmental administrations, and other contracting structures have also been vital to our understanding of the role of design.<sup>xxx</sup> We have been able to utilise examples from the archives at almost every stage of the design process, allowing us to reconstruct the journey from initial identification of a problem or opportunity to the design and application of a new technology. However, there were also many gaps and silences in the archival records. These were particularly evident around the working practices of engineers and on shop floors. In many cases, only very sketchy materials were left to the archives – perhaps a rough hand drawn sketch, with a few guiding notes, might be all we had to discuss how design detailing actually happened. We have therefore to some extent drawn on modern processes and thinking around design to fill some of these gaps. It should also be noted that much of the communication we are

interested in at these stages must have been, firstly, primarily verbal in nature, and secondly, left in the hands of the mechanics and technicians on shop floors to work out for themselves. It is clear that many engineers worked in relatively unstructured ways, particularly compared to contemporary norms, even those employed by some of the largest British engineering firms, such as North British Locomotive, Sir William Arrol & Co., or Head, Wrightson & Co.

The structure of *Design and Communication* broadly follows the chronology of the design process. Chapter one explores the identification of design opportunities within Britain and the empire, examining the mechanisms of market identification, the processes by which opportunities were identified and leveraged to allow the initial development of technology to begin. The nature of the communication between and within the British industrial-economic context and the colonial context is also explored, through discussion of the maturity of technology, colonial opportunities and restrictions and lastly, ownership structures and partnerships. Chapter two examines the design specification stage; that is, how engineers or inventors prepared to design products according to the user and customer requirements, existing competition, and lastly, the technical requirements. Chapter three looks at the concept design stage; the processes by which engineers generated and evaluated their ideas for new designs or adapted technology. It then seeks to understand the structure and nature of collaborations between engineers and the users and/or commissioners of products in the embodiment of these designs. It also gives consideration to the role of patents and intellectual property as a potential conduit for communication in its own right. Chapter four examines the concluding activities of the design process: detail design, manufacture and distribution. That is, the processes by which concept designs were converted into working prototypes, tested and then applied to the required contexts. This includes a discussion of the experimentation, analysis and iteration of designs based on feedback. It then traces the communication of the new design from workshop to the shop floor and the beginning of the manufacturing and production process. Lastly, it explores the imperial linkages put in place to move designs and products to new

contexts – and how these reinforced communication channels within and across empire.

*Design and Communication* aims to develop a more nuanced understanding of the interaction of design across the British World. Due to the nature of the design identification, specification and detailing in the period under examination, much of the action takes place within the British geographical context, but we are careful to highlight the differing contexts within the metropole throughout. We start our examination with the identification of design opportunities and how British and imperial markets acted as a conduit for – but also sometimes restricted – communication.

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<sup>i</sup> Museum of English Rural Life, TR FOW, PI/A6, John Fowler & Co, catalogues, vol. 8 (1900-1903).

<sup>ii</sup> See for example, P. Palladino and M. Worboys, 'Science and Imperialism', *Isis*, 84:1 (1993), pp. 97, 99.

<sup>iii</sup> See for example, Andersen, *British Engineers and Africa*, p. 12; D. R. Headrick, *The Tentacles of Progress: technology transfer in the age of imperialism, 1850-1940* (Oxford, 1988), pp. 49, 52.

<sup>iv</sup> See for example, W. J. Macpherson, 'Investment in Indian Railways, 1845-1875,' *Economic History Review*, 8:2 (1955), p. 177; R. J. Moore, 'Imperial India, 1858-1914,' in A. Porter (ed.) *Oxford History of the British Empire: the nineteenth century* (Oxford, 1999), p. 435.

<sup>v</sup> Arnold, 'Europe, technology and colonialism,' p. 89-90.

<sup>vi</sup> M. Adas, *Machines as the Measure of Men: science, technology and ideologies of Western dominance* (Oxford, 1989), pp. 15, 143-4, 310.

<sup>vii</sup> P. J. Cain and A. G. Hopkins, *British Imperialism: innovation and expansion, 1688-1914* (London, 1993), pp. 17-29, and pp. 243; S. Dubow (ed.), *Science and Society in Southern Africa* (Manchester, 2000), p. 3.

<sup>viii</sup> Cain and Hopkins, *British Imperialism*, pp. 233, 316-18.

<sup>ix</sup> A. Thompson, *The Empire Strikes Back? The impact of imperialism on Britain from the mid-nineteenth century* (Harlow, 2005), p. 164; Cain and Hopkins, *British Imperialism*, pp. 327-33.

<sup>x</sup> J. Gallagher and R. Robinson, 'The Imperialism of Free Trade, 1815-1914,' *Economic History Review*, 2<sup>nd</sup> ser., 6 (1953), p. 14; Cain and Hopkins, *British Imperialism*, p. 235; C. B. Davis and K. E. Wilburn, *Railway Imperialism* (London, 1991), 'Introduction', R. Robinson, pp. 2, 5; Arnold, 'Europe, technology and colonialism,' pp. 95-6.

<sup>xi</sup> Z. Laidlaw, *Colonial Connections 1815-1845: Patronage, the Information Revolution and Colonial Government* (Manchester, 2005), p. 5.

<sup>xii</sup> B. Attard and A. Dilley, 'Finance, Empire and the British World,' *Journal of Imperial and Commonwealth Studies*, 41:1 (2013), pp. 2, 5; A. Smith, 'Patriotism, self-interest and the "Empire Effect": Britishness and British decisions to invest in Canada, 1867-1914,' *Journal of Imperial and Commonwealth Studies*, 41:1 (2013), pp. 63, 65; Thompson, *Empire Strikes Back?*, pp. 170-1; A.

Thompson and G. Magee, 'A Soft Touch? British Industry, Empire markets and the self-governing dominions, c. 1870-1914,' *Economic History Review*, 56:4 (2003), pp. 690, 691-2, 696, 698; T. J. Hatton, 'The Demand for British Exports, 1870-1913,' *Economic History Review*, 43:4 (1990), pp. 577, 579; Cain and Hopkins, *British Imperialism*, pp. 229-34.

<sup>xiii</sup> R. Floud and D. McCloskey (eds), *The Economic History of Britain since 1700, vol. 2: 1860-1939* (Cambridge, 1994), pp. 206-7, 213; N. Charlesworth, *British Rule and the Indian Economy, 1800-1914* (Basingstoke, 1985), pp. 11-13.

<sup>xiv</sup> For example, consider the differences between geographical locations in the UK such as Leeds, Manchester, Glasgow, Norfolk, London, lowland Scotland: A. Tindley and A. Wodehouse, 'The Role of Social Networks in Agricultural Innovation: the Sutherland Reclamations and the Fowler Steam Plough, c. 1855-c. 1885,' *Rural History*, 25:2 (2014); A. Offer, 'Costs and Benefits, Prosperity and Security, 1870-1914' in A. Porter (ed.), *The Oxford History of the British Empire; the Nineteenth Century* (Oxford, 1999), p. 706.

<sup>xv</sup> S. J. Potter, 'Webs, networks and systems: globalization and the mass media in the nineteenth and twentieth century British Empire,' *Journal of British Studies*, 46:3 (2007), pp. 622, 626, 634

<sup>xvi</sup> Arnold, 'Europe, technology and colonialism,' pp. 98-100.

<sup>xvii</sup> See Andersen, *British Engineers and Africa*, pp. 3, 5, 161-4.

<sup>xviii</sup> A. Lester, 'British Settler Discourse and the Circuits of Empire,' *History Workshop Journal*, 54 (2002), pp. 24-44; K. Raj, 'Colonial encounters and the forging of new knowledge and national identities: Great Britain and India, 1760-1850,' *Osiris*, 2<sup>nd</sup> ser., vol. 15 (2000), pp. 119, 133; A. Lester, 'Imperial circuits and networks: geographies of the British Empire,' *History Compass*, 4:1 (2006), pp. 124-141.

<sup>xix</sup> There is a significant body of literature on this debate already: G. Basalla, 'The Spread of Western Science,' *Science*, 156: 3775 (1967), pp. 611-22; R. MacLeod, 'Introduction,' *Osiris*, 2<sup>nd</sup> ser., vol. 15, Nature and Empire: Science and the colonial enterprise (2000), pp. 1-2, 6, 10.

<sup>xx</sup> See for example, Y. Bektas, 'The Sultan's Messenger: cultural connections of Ottoman telegraphy, 1847-1880,' *Technology and Culture*, 41:4 (2000), pp. 688, 695; R. A. Buchanan, 'The Diaspora of British Engineering,' *Technology and Culture*, 27:3 (1986), pp. 502-3, 507.

<sup>xxi</sup> See for example, J. McIntyre, R. Mitchell, B. Boyle and S. Ryan, 'We used to give and get a lot of help: networking, cooperation and knowledge flow in the Hunter Valley wine cluster,' *Australian Economic History Review*, 53:3 (2013), pp. 247, 253; J. Frawley, 'Prickly pear land: transnational networks in settler Australia,' *Australian Historical Studies*, 38: 130 (2007), 324.

<sup>xxii</sup> These networks could have a number of different bases, for instance, family, ethnicity, professions, religions or economics: see G. Jones and M. B. Rose (eds), *Family Capitalism* (Brookfield, 1993), p. 9; S. Ville, 'Business Development in Colonial Australia,' *Australian Economic History Review*, 38:1 (1998), pp. 20, 27; Andersen, *British Engineers in Africa*, pp. 161-4; A. Thompson, 'The power and privileges of association: co-ethnic networks and the economic life of the British imperial world,' *South African Historical Journal*, 56:1 (2006), pp. 46, 50, 53, 58; J. Weiler, 'Colonial Connections: Royal Engineers and building technology transfer in the nineteenth century,' *Construction History*, 12 (1996), pp. 3, 7, 16; Tindley and Wodehouse, 'The Role of Social Networks in Agricultural Innovation'.

<sup>xxiii</sup> I. Inkster, 'Patents as indicators of technological change and innovation – an historical analysis of the patent data,' *Trans. of the Newcomen Society*, 73 (2003), pp. 183, 187, 193-4.

<sup>xxiv</sup> C. MacLeod, 'Reluctant Entrepreneurs: patents and state patronage in new technosciences, c. 1870-1930,' *Isis*, 103:2 (2012), pp. 333-4; J. Andrew, J. Tann, C. MacLeod and J. Stein, 'Steam power patents in the nineteenth century – innovations and ineptitudes,' *Trans. of the Newcomen Society*, 72 (2000-2001), pp. 17, 25, 33; C. MacLeod, J. Tann, J. Andrew and J. Stein, 'Evaluating Inventive Activity: the cost of nineteenth century UK patents and the fallibility of renewal data,' *Economic History Review*, 56:3 (2003), pp. 539-40, 560.

<sup>xxv</sup> See for instance Adas, *Machines as the Measure of Men*, p. 310; S. Sangwan, 'Indian response to European science and technology, 1757-1857,' *British Journal for the History of Science*, 21:2 (1998), pp. 217, 231; D. W. Chambers and R. Gillespie, 'Locality in the History of Science: colonial science, technoscience and indigenous knowledge,' *Osiris*, 2<sup>nd</sup> ser., vol. 15 (2000), pp. 222-3, 227, 231.

<sup>xxvi</sup> See for example, J. M. Mackenzie, *Propaganda and Empire: the manipulation of British public opinion, 1880-1960* (Manchester, 1986) and the alternative view put by B. Porter, *The Absent-Minded Imperialists: empire, society and culture in Britain* (Oxford, 2006).

<sup>xxvii</sup> For example, in sugar production technologies: A. H. Adamson, *Sugar without slaves: the political economy of British Guiana, 1838-1904* (London, 1972), p. 6, 9, 171-2; M. Craton and J.

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Walvin, *A Jamaican Plantation: the history of Worthy Park, 1690-1970* (London, 1970), pp. 156, 219-22.

<sup>xxviii</sup> For example see, P. S. A. Berridge, *Couplings to the Khyber: the story of the North Western Railway* (Newton Abbot, 1969), pp. 80, 209; Headrick, *Tentacles of Progress*, pp. 51-2, 82; F. Lehmann, 'Great Britain and the supply of railway locomotives to India: a case study of "economic imperialism"', *Indian Economic and Social History Review*, 2 (1965), pp. 298, 301-2.

<sup>xxix</sup> J. R. Ward, 'The industrial Revolution and British Imperialism, 1750-1850,' *Economic History Review*, 47:1 (1994), pp. 44-6.

<sup>xxx</sup> A full list of the archives used in this study is given in the Bibliography.